

A REPORT ON A COLLECTION OF AMPHIBIANS AND REPTILES FROM THE PONMUDI, KERALA, SOUTH INDIA¹

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(With three plates)

INTRODUCTION

Knowledge of the herpetofauna of southwestern India has developed over the last 130 years through the efforts of many persons, generally as a result of accumulation of small collections from scattered localities. From the volume by Boulenger (1890) on amphibians and reptiles, the two volumes by Smith (1935, 1943) on lizards and snakes, and the numerous papers of N. Annandale, J. C. Daniel, R. S. Pillai, and C. R. N. Rao on amphibians, one can piece together a picture of the species diversity of the herpeto-fauna of this humid region of the subcontinent. However, until very recently, there has been no basis for estimating local diversity, because specific localities, as opposed to district place names, have not always been given. The first collection likely to provide an estimate of local diversity is that recently made at Silent Valley, Kerala, by Dr. R. S. Pillai of the Zoological Survey of India. We report here on a second, large local sample, this one from Ponmudi in southern Kerala, about 250 km south of Silent Valley and about 170 km south of the Anamallai Hills. This sample, collected May 3-June 17, 1982, was obtained as

part of a joint project of the National Museum of Natural History, New Delhi (NMNHI) and the Field Museum of Natural History, Chicago (FMNH). The material is now housed in both institutions.

The area in which this collection was made centered on the Ponmudi ridge (8°45'N, 77°8' E) and its slopes, from about 100 m above sea level to its crest at 1095 m. The extent of the area actually searched is difficult to determine, but we estimate that no site was more than 10 km (in a direct line) from the crest of the Ponmudi ridge and most were less than 5 km. The forest is now broken into large blocks of varying sizes, the largest in which we worked being 4-8 km wide. Intervening cleared areas are mainly large tea plantations. The dominant types of forests are designated by the Forestry Department, State of Kerala as tropical evergreen, moist deciduous, and, at the highest elevations only, low tropical evergreen (Adriel 1966). Most of our sampling was carried out in the first type, which has the typical 3-storied structure of tropical evergreen forest and an abundance of lianas, at elevations between 310 and 370 m. Rainfall is heavy (annual mean at Ponmudi 4603 mm) and seasonal. Between 1952-1961, only three months—January, February, and March—averaged less than 100 mm of rain. As the topographic relief is steep, the streams have beds of sand, gravel, and rock and moderate

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to strong current. Pools alternate with riffles and, in many places, low waterfalls. Most of the streams flow throughout the year. Those along which we sampled varied from 0.5 to 4 m in width.

MATERIALS AND METHODS

Specimens were obtained by a party of 4-10 men collecting along streams and through patches of forest during daylight and early night hours. Rocks were turned, dead leaves scraped, and logs rolled and their bark stripped. Shrubs and trees were examined as high as the dim light and obscuring branches permitted. In addition, we used two procedures to guarantee close inspection of large areas of forest floor: (1) examination and removal of litter from buttress-enclosed areas at the bases of large trees, and (2) search of forest floor quadrats (see description of latter method in Lloyd *et al.* 1968). Although we include all specimens in this report, those obtained by the last two methods will be subject to special analysis in a subsequent publication.

As each specimen was captured, we placed it in a separate plastic bag and recorded its position when first sighted in terms of a complex microhabitat classification. We used the system described in Inger and Colwell (1977), expanded slightly to include all vegetation types encountered at Ponmudi. Upon return to the field laboratory, animals were anaesthetized, preserved in formalin, and each (with few exceptions) tagged with a separate number within three hours of capture. We maintained a few lizard eggs in plastic bags until hatching and kept some frog eggs until larvae reached early developmental stages.

In the text we give snout-vent lengths (SV) of adults, standard scale counts where appropriate, and body proportions relative to SV. For each species of frog, the smallest female

having convoluted oviducts or developing ova sets the minimum size for maturity for females of that species; the smallest male having developed secondary sex characters serves the same purpose for males. Frog larvae are staged according to the scheme developed by Gosner (1960). Denticle formulae for larvae are presented in the standard form of using Roman numerals for undivided rows and Arabic numerals for divided ones. A slash separates the counts for upper and lower lips.

Elevations above sea level in metres (m) were determined with a Thommen pocket altimeter and are accurate to approximately 30 m.

Gegeneophis carnosus (Beddome)

Epicrium carnosum Beddome, 1870 Madras Month. J. Med. Sci., 2 : 176 — Periah Peak, Wynad.

Gegeneophis carnosus Boulenger, 1882, Cat. Batr. Grad. Brit. Mus., p. 101, pl. 8, fig. 3.

Material. A single specimen: total length 260 mm, width 7.5 mm, primary folds 120, secondary folds 6.

This specimen is uniform gray above and tannish-gray on the sides and vent. Anus transverse, tail absent; eye completely hidden.

Gegeneophis is similar to *Indotyphlus*. For our material, Taylor's (1961) key is not helpful since the position of the tentacle relative to the eye and nostril cannot be determined. Our specimen agrees well with Taylor's (1961) description in body proportions (width into length 35), color, and fold counts, all of which distinguish it from other *Gegeneophis*.

Ecological Notes. Our specimen was collected beneath a 25 cm rock along the bank of a 0.5 m wide stream in evergreen forest at 350 m elevation. Five eggs were found with the specimen. Daniel (1963) notes that individuals have been collected previously in the Ponmudi hills; specimens with eggs were reported by Seshachar (1942) from Tenmalai.

Ichthyophis beddomei Peters

Ichthyophis beddomei Peters, 1879, Monatsb. Akad. Wiss., Berlin, 1879: 932, fig. 4 — Nilgiri Hills.

Material. A single specimen: total length 190 mm, width 9.5 mm, body folds 304.

Dark brown above, light brown below, with a light yellow lateral stripe along each side. The stripe extends onto the head as far as the angle of the mouth, and is somewhat expanded dorsoventrally in the cheek region. The eye is clearly visible, and the tentacle is along the upper lip margin and about equidistant between the eye and nostril.

Our material agrees well with Taylor's (1961) diagnosis other than its slightly high fold count; Taylor lists 240-293 for 16 individuals.

Ecological Notes. This specimen was caught under a rock at the base of a tree in evergreen forest at 560 m above sea level.

Bufo beddomi Günther

Bufo beddomii Günther, 1875, Proc. Zool. Soc. London, 1875: 569 — Malabar.

Material. 3 adult females 36.8-45.1 mm SV, mean 40.2; 1 male 31.1 mm; 10 juveniles, 11.0-17.2 mm. Tibia 0.40-0.45 of SV in females, 0.48 in male.

Above uniform dark brown; a faint black barring pattern on the hind legs and feet. Beneath tan, with an irregular marbling of dark brown. In life, the dorsal surfaces of the feet reddish-brown, contrasting sharply with the dorsal color.

Immature individuals may be difficult to distinguish from sympatric *B. parietalis* since both lack bony ridges on the head. However, even the smallest *B. beddomi* (11 mm SV) are densely covered with sharp, conical warts on the dorsum, head, and eyelids, and have warty paratoids with uneven indented margins. Young *B. parietalis* have extremely fine

spicules on the head and eyelids, grading into larger, thinly dispersed warts on the paratoids and back; the paratoids are oval, smooth-edged, and underlined in black laterally.

Ecological Notes. Thirteen of our 14 individuals were collected in evergreen forest at 310 m, and one was taken in gallery forest. All specimens were collected away from streams, eight on the surface of dead leaves, two on bare soil, and four on small rocks. Eleven specimens were found during the day and three at night.

Bufo melanostictus Schneider

Bufo melanostictus Schneider, 1799, Hist. Amphib., p. 216 — East India.

Material. 4 adult females 45.3-58.1 mm SV, mean 52.8. Tibia 0.37-0.43 of SV. All contained numerous pigmented ova.

Ecological Notes. An inhabitant of cleared or disturbed habitats, including rubber plantings, forest edges, and human habitations. Individuals were collected from sea level to 900 m, and numerous additional specimens were seen but not collected, especially in the immediate vicinity of human dwellings.

Bufo parietalis Boulenger

Bufo parietalis, Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 312, plate 21, fig. 22 — Malabar.

Material. 7 adult females 73.7-92.2 mm SV, mean 82.4; 4 adult males 50.1-59.9 mm, mean 54.7; 11 subadult females 55.9-66.1 mm; 67 juveniles 14.6-45.3 mm. Tibia 0.37-0.40 of SV in females, mean 0.385; 0.38-0.42 in males, mean 0.396.

Very little has been published on this toad since its original description. Adults have a uniform light brown dorsum with a few large warts, usually tipped with black. A dark line extends from the orbito-tympanic crest along the lateral edge of the paratoid gland, and is present even in small juveniles. The sides are

dark brown marbled with tan. The cranial crests are extremely well developed in adults, with the paratoid ridge meeting the paratoid gland. The crests become progressively keratinized and blackened with age, starting with the supraorbital crest in young adults, until all crests are heavily keratinized in large specimens. The young lack cranial crests. To distinguish them from sympatric toads, see *B. beddomi*.

Ecological notes. Fifty-four individuals were collected from evergreen forest, 24 from moist deciduous forest, 2 in secondary growth and 3 in semi-evergreen forest. Twenty-three were caught below 200 m elevation, 56 at 250-400 m, and 4 at 950 m. Most toads were found away from streams in the forest (68 specimens); 12 were collected along stream banks, and two were in the water of streams. Forty-five individuals were collected on the surface of dead leaves, 14 on bare soil, and 10 on rocks; the remaining individuals were either under leaves, rocks, or soil (7) or on logs or low plants (3). Only one female (86.2 mm) contained mature ova.

Pedostibes tuberculosus Günther

Pedostibes tuberculosus Günther, 1875, Proc. Zool. Soc. London, 1875: 576, pl. 64, fig. C — Malabar.

Material. 1 adult female 38.5 mm SV. 1 adult male 36.6 mm, 16 juveniles 11.1-21.9 mm. Tibia 0.44 of SV in female, 0.40 in male. Ova in the female were very small.

Ecological Notes. Sixteen of our 18 individuals were collected in evergreen forest at 300-310 m elevation, 1 in moist deciduous forest (255 m) and 1 in moist semi-evergreen forest (260 m). We found 11 individuals away from streams and 7 within 6 metres of a permanent stream. Seven were on dead leaves, 2 on bare soil, 5 on small rocks, 3 on leaves of herbaceous plants, and 1 on a shrub. Our

limited observations suggest that these toads stay on or near the ground during daylight hours (9 were collected on the forest floor), then move to arboreal situations at night (3 on leaves of small shrubs). However, we also found one individual 1.5 m above ground in a shrub during daylight hours, and one of our four night captures was on a 10 cm rock on the ground, suggesting that this temporal habitat selection is not perfect.

Ramanella triangularis (Günther)

Callula triangularis Günther, 1875, Proc. Zool. Soc. London, 1875: 576 — Malabar.

Ramanella triangularis Rao and Ramanna, 1925, Proc. Zool. Soc. London, 1925: 1445.

Material. 1 adult female 30.3 mm SV; 4 adult males 23.4-25.8 mm, mean 24.2. Tibia 0.42 of SV in female; 0.42-0.47 in males, mean 0.44. The female was gravid.

Taxonomic Notes. According to Parker (1934), *R. triangularis* is distinguished from *R. variegata* (Stoliczka) on the basis of toe webbing (a rudiment in *R. variegata*, toes completely free in *R. triangularis*), ventral coloration (immaculate white in *R. variegata*, dark brown with small, white spots in *R. triangularis*), and the dorsal color pattern. *Ramanella triangularis* has a characteristic dark lateral streak at the loreal region and a dark dorsal median blotch that bifurcates in the coccygeal region. The color pattern of *R. variegata* is dark brown with irregular lighter marblings or spots, but no consistent pattern (Parker 1934, Daniel 1963). Our specimens agree with *R. triangularis* in ventral coloration and in some details of the dorsal color pattern, particularly in the dark triangular blotch between the forelimbs. However, the paired dark bands posteriorly and the triangular dark spot enclosing the anus are both variable. In addition, our specimens have vestiges of webbing on the toes, extending to the proximal sub-

articular process of the third, fourth, and fifth toes. Thus, while we identify these frogs as *R. triangularis* on the basis of color pattern, they actually represent a composite of key characteristics of both species, and suggest that rediagnosis of the two species may be needed.

Larvae. Eleven samples of a larval microhylid were obtained from tree holes. None is older than Stage 27, so that diagnostic features of adult limb form are not available. Of the microhylid genera known from South India, the only one that has arboreal habits is *Ramanella* (Daniel 1963). Since it is not likely that any of the other, terrestrial genera would consistently deposit eggs in tree holes, we believe that these are larval *Ramanella*.

Larvae have been assigned to *R. triangularis* (Rao 1918, Parker 1934), with no explanation for this decision. Rao gave no information on habitat. Our tadpoles differ from Rao's in several respects. First, they are blackish, heavily pigmented dorsally, laterally, and under the fore part of the body. Rao's tadpoles were transparent, becoming brown in metamorphic stages. Secondly, the Ponmudi larvae have the spiracular tube extended to the end of the body so that the opening overlies the end of the anal tube; Rao's figure shows the spiracle opening almost midway between the level of the eyes and the end of the body. Description of our larvae follows.

Head-body broadly oval, almost truncate at snout, body depressed, maximum width at mid-body; eyes lateral, but not visible from below; eyeball very small in these stages; interorbital about 0.6 of head-body width, at least 1.5 times eye-snout distance; nostrils not open, internarial $1/4$ - $1/3$ of interorbital; nasolacrimal duct not visible. Mouth terminal; neither lip expanded; no beaks or denticles; upper lip with obtusely pointed, down-

turned lateral lobes separated by wide, curved median indentation; lower lip supporting a U-shaped flange projecting into buccal cavity with median portion forming part of exterior surface of mouth just below center of upper lip. Spiracle median, opening wide, overlying end of anal tube. Anal tube median, in ventral fin running diagonally from end of body to margin of fin. Tail weakly convex, tapering gradually to narrow tip; both fins arising at end of body; fins deeper than muscle in distal two-thirds; ventral fin deeper than dorsal. Head-body black above, laterally, and under anterior half or two-thirds; no pattern; caudal muscle and dorsal fin dusky; ventral fin usually without pigment.

Head-body length (mm) at Stage 25 7.1 (maximum), at Stage 27 9.2-9.25. Maximum total length 25.5 mm. Tail length 1.56-1.76 of head-body length. Head-body width 0.68-0.88 of length; body depth 0.62-0.67 of width; eyeball 0.06-0.07 of head-body length.

Ecological Notes. All 5 adults were taken from two tree holes in the same tree 2-4 m above the ground in an isolated patch of evergreen forest at 950 m above sea level. Tadpoles were collected in the same tree holes as well as in others 0.3-1.0 m above ground at 310-510 m above sea level.

Micrixalus fuscus (Boulenger) (Plate I)

Ixalus fuscus Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 96, pl. 10, fig. 3 — hills of southwestern India.

Micrixalus fuscus Boulenger, 1888, Proc. Zool. Soc. London, 1888: 205.

Micrixalus herrei Myers, 1942, Proc. Biol. Soc. Washington, 55: 71 — Kallar, Trivandrum District.

Material. 50 adult females 21.5-28.8 mm SV, mean 25.2; 126 males 17.6-21.2 mm, mean 19.5; 71 juveniles and subadults 11.3-20.8 mm. Tibia 0.49-0.56 of SV in females,

mean 0.534 (n=10); 0.55-0.62 in males, mean 0.566 (n=10). Males have large, cream-coloured nuptial pads.

An extremely variable species, showing a wide range of variation in color pattern and amount of webbing of the feet. Dorsum in life light tan to dark reddish brown to nearly black, with various amounts of black marbling or spotting. Ventral color yellow-tan, with or without brown reticulations, especially in the throat region. Thin dorsolateral fold white, black, or similar in color to the tan background. A light thigh stripe extending from anus nearly to inside of the knee joint always present, even in very small juveniles, sometimes interrupted. In life, thigh stripe deep yellow. Females bright yellow in the groin and on anterior face of the thigh; males have the yellow less developed. Dorsal surfaces of the feet bluish-gray.

Webbing of the hind feet varies from about three quarters (Daniel 1963) to nearly complete. The variation found in this species, especially in the extent of hind foot webbing, would be sufficient to distinguish a separate species if only the extremes were considered. However, since no clear break in the amount of webbing exists, and it is not correlated with color pattern or other variation, we conclude that this entire sample represents a highly variable, continuous population.

Eggs of most females were enlarged, ripe, and unpigmented. Males have large nuptial pads.

Taxonomic Notes. Myers (1942b) named *M. herrei* on the basis of a single male taken from Kallar, a few kilometres from several of our collecting sites. These two species were differentiated by Myers on the basis of six characters: 1) longer legs of *herrei*, 2) dorsum granular in *herrei*, 3) snout more rounded in *herrei*, 4) a relatively larger eye in *herrei*, 5)

herrei's much smaller size, and 6) certain differences in details of coloration. In comparing the type and only specimen of *M. herrei* (CAS SU 7265) to our large series, we find that most of the diagnostic features are variable in our series. Characters 1 and 5 are sexually dimorphic in this species, and the type of *herrei* is well within the range of our series of males. Likewise, the color pattern differences between the two disappear when a large series is examined. The granular surface of *herrei*, as Myers suggested, is primarily a function of the drying out of a specimen, and an individual changes from "smooth" to "granular" in the course of a few minutes of desiccation. The shape of the snout in our material is more similar to *M. herrei* than the figure of *M. fuscus* in Boulenger (1882), with the nostrils slightly interrupting the line of the canthus rostralis. However, this difference is extremely slight. The eye diameter relative to the distance from eye to snout is large in *M. herrei* (3.0 : 2.5 mm), as Myers indicated. This character is sexually dimorphic in our sample, and females have relatively smaller eyes than males. In a random sample of 12 individuals, the largest eye size was 2.9:2.7 mm, and on average the ratio is about 1:1. It thus seems likely that Myers' type represents nothing but a slightly large-eyed male *M. fuscus*, and that specific designation is unwarranted.

Ecological Notes. Of the 239 specimens for which we have ecological data, most (222) were taken in evergreen forest (2 below 200 m, 192 at 200-400 m, 28 at 401-750 m). The rest were found in moist deciduous forest (13), moist semi-evergreen forest (1), or secondary growth (1) between 70 and 400 m. A single individual was collected at 950 m in gallery forest. About a third of our specimens were found away from streams in the forest; the

remainder were collected either in the water (8), on rocks in midstream (30), or along the banks (122) of permanent and intermittent streams. Most individuals were found on the forest floor, either on rocks (115), dead leaves (71), or on bare soil (9); the rest were taken above ground in low plants (22) or under dead leaves (7). A large concentration of this species was always present in a seepage area, with flowing water 2-5 cm deep, and several pairs were found in amplexus in this area.

Micrixalus nudis Pillai

Micrixalus nudis Pillai, 1978, Proc. Indian Acad. Sci., 87B: 173 — Chedleth, Kurichiat Reserve Forest, Wynad, Kerala.

Material. 6 adult females 18.1-19.7 mm SV, mean 19.2; 6 adult males 15.2-15.6 mm, mean 15.4. Tibia 0.47-0.51 of SV in females, mean 0.494; 0.49-0.53 in males, mean 0.511. Males have a well developed nuptial pad. All six females contained large well-developed, unpigmented ova.

This sample matches Pillai's (1978a) description, and represents the second series of the species. The only disparity with the type series is in the extent of webbing on the hind feet. Our specimens have only a rudiment of webbing, while Pillai's series was about half webbed. However, in size, details of color pattern, and other aspects of morphology, the agreement is nearly perfect. The extensive variation in webbing found in our large sample of *M. fuscus* from Ponmudi suggests that this character may be relatively variable in this genus.

Ecological Notes. We found these frogs at 250-900 m elevation, in evergreen (5), moist deciduous (3) and gallery (4) forests. Half of the individuals were found away from streams; the rest were in small streams (1) or

along stream banks (5). We collected 5 specimens on rocks, 2 on dead leaves, 2 on tree trunks, 1 on bare soil, and 1 on a fallen log.

Pillai's (1978a) report of pairs in amplexus in late October, combined with our observations, suggests that these frogs breed at least throughout the monsoon season (May-October).

Our specimens extend the range of *M. nudis* approximately 350 km southward, and suggest that the species is widely distributed throughout the Western Ghats.

Nannobatrachus beddomi Boulenger

Nannobatrachus beddomii Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 470 — Malabar and Tinnevely. *Nannobatrachus anamallaiensis* Myers, 1942, Proc. Biol. Soc. Washington, 55: 49 — Puthutotam Estate, Valparai, Tamil Nadu.

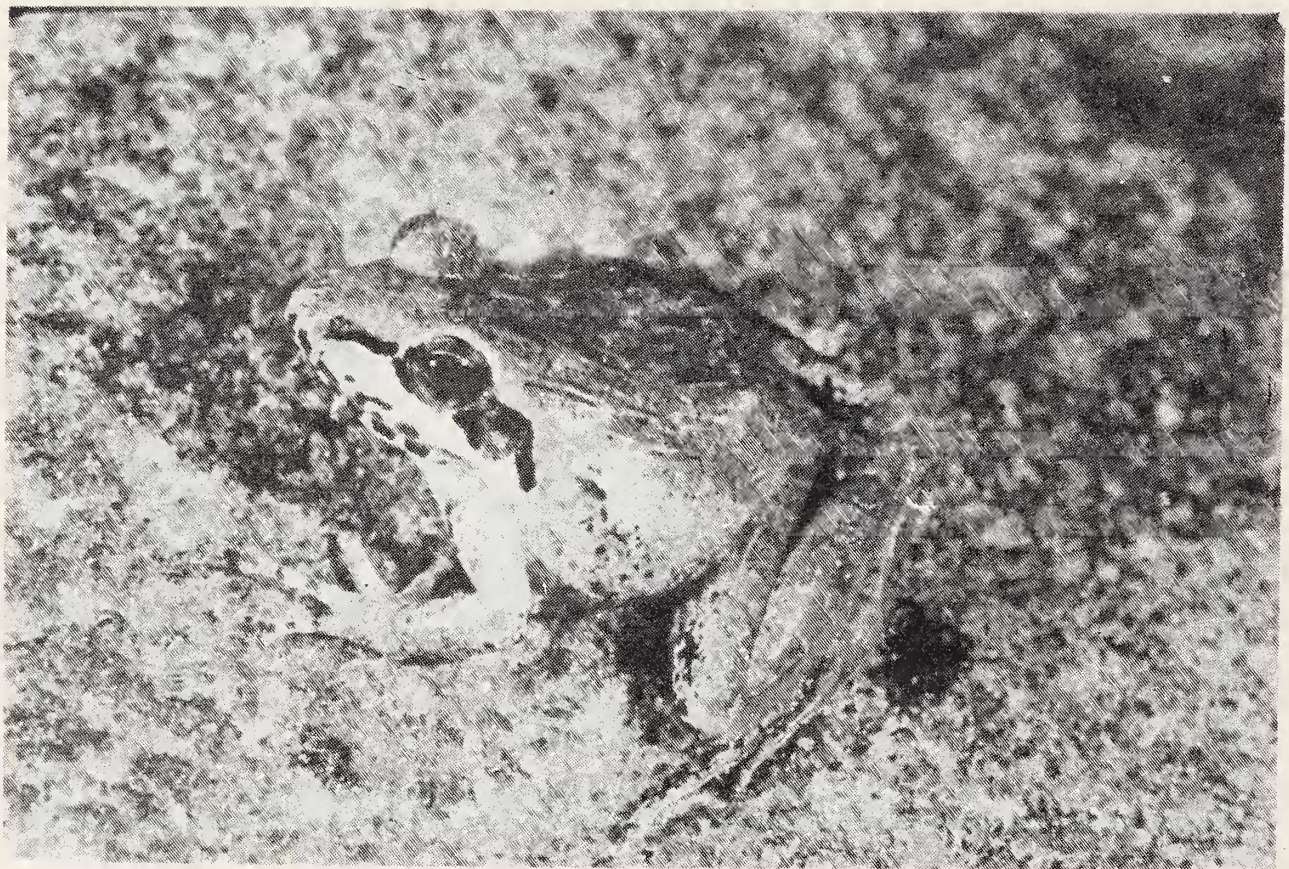
Material. 10 adult females 14.5-17.1 mm SV, mean 15.7; 8 adult males 13.6-15.2 mm, mean 14.5; 4 juveniles and subadults. Tibia 0.45-0.49 of SV in females, mean 0.470; 0.45-0.51 in males, mean 0.483.

Our sample agrees well with the original description as emended by Boulenger (1883). A stout, squat species with a broadly rounded snout, no canthus rostralis, large, well-separated eyes with very small eyelids. Skin perfectly smooth dorsally and ventrally; a few small conical tubercles may be present on the eyelids. Toes long and slender, with small, oval disks and no trace of webbing. Toe disks with longitudinal division dorsally, and a strong circum-marginal groove. No groove on the finger disks. Tympanum completely hidden in some individuals, barely visible in others, and about half the diameter of the eye.

In life, back brown with black markings; throat and abdomen grayish. A pale, bluish-white streak behind and below eye, and an irregular series of similar spots along sides of neck and torso. A tan, triangular patch on the snout



Above: Micrixalus fuscus.
Below: Nyctibatrachus major, showing diamond-shaped pupil.



Above: Nyctibatrachus minor, new species.
Below: Rana brachytarsus.

between eyes. Front and hind limbs strongly barred with dark brown crossbands.

Of 11 mature females, 8 contained large, pigmented, black and tan ova and a few small white ones, while three contain only small, unpigmented ova. Males have the relatively largest and most strongly developed femoral glands⁴ of any species in our collection. The glands are oval, raised, enamel white in color, and about two-thirds the length of the femur. However, in one male the glands are much less developed; they are barely raised above the surface of the thigh and have lost most of their distinctive white color.

Taxonomic Notes. We have compared our material with a cotype of *N. beddomi* (FMNH 73344) and with part of the type series of *N. anamallaiensis* Myers (CAS 7199, 7200, 7202, 7204). The remaining species of the genus, *N. kempholeyensis* Rao was not available for comparison. Our material agrees in nearly every detail with the *N. beddomi* cotype, and is clearly assignable to that species. However, the differences between *N. beddomi* and *N. anamallaiensis* cited by Myers are extremely slight.

Myers (1942a) cites the shape of the pupil, the relatively shorter hind leg, and the shape of the vomerine tooth patch (linear in *anamallaiensis*, oval in *beddomi*) as the only differences between these two species. As Rao (1937) and Pillai (1978b) have pointed out, the shape of the pupil in preserved frogs is too variable to be of much systematic value. In our series, 16 specimens have perfectly round pupils; the rest vary from slightly oval to diamond-shaped, similar to the condition we observed in living examples of *Nyctibatra-*

chus (Plate I). Several specimens had one round pupil and the other oval shaped. There is also considerable variation in the shape of the vomerine tooth patch in our material. These tiny frogs have only 5-10 teeth per patch, and the eruption of a few teeth can completely change a patch from linear to oval. Hind limb length, especially when measured as the position the tibio-tarsal joint reaches along the head, is also variable, depending on the amount of food in an individual's stomach or the ova in a female. Measured as the overlap of the heels when the femurs are at right angles to the body, measurement error is much less, and both *anamallaiensis* and *beddomi* have legs of equal length, with the heels just or not quite meeting at the anus. We feel, therefore, that *N. anamallaiensis* is a junior synonym of *N. beddomi*, and that Myers' detailed description of the former may be used as a needed redescription of *N. beddomi*. No traces of femoral glands or enlarged ova are in evidence in Myers' four examples. They were collected in January, which is apparently not a part of the breeding season. Thus, the femoral glands may well be strictly seasonal in occurrence.

As Myers (1942a) suggested, the generic relationships and distinctiveness of *Nannobatrachus*, *Nyctibatrachus*, and *Nannophrys* are problematical. Of the characters first used to separate these genera, pupil orientation can no longer be considered of systematic value. Toe webbing, cited by Myers as a feature of *Nyctibatrachus*, is also no longer valid, since a new species described below lacks webbing. Two previously unused characters, which we describe for the five species available to us, are the presence of femoral glands in males and the presence of pigmented ova in reproductively mature females. These characters, when considered in combination with the pre-

⁴ We are grateful to Mr. Barry Clarke, British Museum (Natural History), for calling our attention to the femoral glands in *Nyctibatrachus*, leading us to look for these structures in *Nannobatrachus*.

sence of skin folds and webbing, allow an unambiguous characterization of all five taxa (see Table 1). However, they do not help diagnose *Nannobatrachus* and *Nyctibatrachus*. Further analysis of the osteological characters used by Boulenger (1882) and Myers (1942a) may help resolve this problem.

femoral glands in sexually mature males, toes three-fourths webbed, and dorsal coloration of brown and tan with light dorsolateral bands.

Holotype. Field Catalogue number RFI-31300, an adult female collected 1 June, 1982 from Ponmudi, Trivandrum District, Kerala, 350 m elevation. Deposited in NMNHI.

TABLE 1

COMPARISON OF PONMUDI SPECIES OF *Nannobatrachus* AND *Nyctibatrachus* WITH EACH OTHER AND WITH *Nyctibatrachus pygmaeus*

Species	Ripe Ova	Femoral Glands	Skin Folds	Webbing*
<i>Nannobatrachus beddomi</i>	pigmented	strong	absent	< 1/4
<i>Nyctibatrachus major</i>	pigmented	strong	present	3/4
<i>N. aliciae</i>	pigmented	weak	present	3/4
<i>N. pygmaeus</i>	pigmented	strong	present	1/2
<i>N. minor</i>	unpigmented	absent	present	< 1/4

* Extent of webbing relative to subarticular tubercles of fourth toe: < 1/4 = not beyond basal tubercle; 1/2 = to middle tubercle; 3/4 = between middle and distal tubercles.

Ecological Notes. We collected specimens in evergreen forest (13 at 260-365 m, 4 at 450-660 m), moist deciduous forest (2 at 280-290 m), moist semi-evergreen forest (2 at 260 m), and high-altitude gallery forest (1 at 900 m). Eight specimens were taken along stream banks, 12 away from streams, and one in the dry bed of an intermittent stream. About two-thirds of our specimens were collected beneath cover (6 under leaves, 6 under rocks, 1 under soil); the rest were on dead leaves (3) or bare soil (2).

*Nyctibatrachus aliciae*⁵ sp. nov.

Diagnosis. A medium-sized *Nyctibatrachus* which can be distinguished from all other forms by its intermediate size at sexual maturity (mean SV for males 22.7 mm, for females 26.5 mm), presence of weakly developed

Paratypes. 24 adult females, 8 adult males, 2 juveniles. FMNH 216582-602; 13 deposited in NMNHI.

Description of holotype. Habitus squat and stout, as in other members of the genus. Snout rounded, no canthus rostralis. Nostrils close together, about one-third the distance from the tip of the snout to the eye, internarial distance slightly less than interorbital. Upper eyelids very reduced, covering less than one-quarter of the eyeball; interorbital distance more than twice the width of the eyelid. A well defined supratympanic fold from the middle of the posterior edge of the eye curving

⁵ We take pleasure in naming this species for Dr. Alice G. C. Grandison, British Museum (Natural History) as a modest token of appreciation for her help not only to us, but to herpetologists around the world.

through a 90 degree bend to the shoulder. Tympanum completely hidden.

Forelimbs stout. Fingers long, slender, and unwebbed. Tips of the fingers dilated into small, round disks, only slightly larger than the diameter of the subterminal phalanx. A well developed circummarginal groove separating the dorsal and ventral surfaces of the disk extends almost around its entire circumference. Disks on all fingers with a dorsal longitudinal groove, the division very weak on the first finger, most pronounced on the third. Subarticular tubercles moderate; a series of three tubercles at the base of the metacarpals, the one under first finger largest.

Hind legs robust, short, the heels widely separated when the tibia are bent at right angles to the body. Tibia 0.49 of SV. Toes three-fourths webbed (see Daniel 1963, figure 12), webbing extending to disk of all but fourth toe on lateral sides, and to outer subarticular tubercle on fourth. Webbing extends slightly past distal subarticular tubercle on medial side of third toe and to base of disk on medial side of second. A thin fringe of webbing, which tends to fold over on the phalanx, from distal subarticular tubercle of fourth toe to disk. Disks much larger than on fingers, one and one-half times breadth of subterminal phalanx. A strong circummarginal groove; dorsally, all disks strongly divided.

Subarticular processes well developed, oval, and whitish-gray in color. A long, slender inner metatarsal tubercle, about three times as long as wide, and a small, white nearly round outer tubercle. A slightly crescentic tarsal fold extending from anterior edge of inner metatarsal tubercle about two-thirds distance to tibio-tarsal joint. A low, spinose ridge along the lateral side of the foot, ending in outer metatarsal tubercle.

Skin loosely connected to underlying tissue,

even on head and limbs. Dorsally an irregular series of short ridges completely covering the back and limbs; ridges on snout becoming longer and assuming a more or less parallel longitudinal orientation. A strong, well-developed ridge extending from the lip over the tip of the snout to between the nostrils, at which point it bifurcates, producing an inverted "Y"; the bifurcated ends extend half the distance to the eyes. Upper eyelids strongly tuberculate. Numerous tiny, white-tipped tubercles on the upper surface of the calves and tarsus and above the vent. Belly smooth, the throat with a series of longitudinal ridges sharply demarcated by a gular fold. The underside of the limbs smooth.

Dorsally a dark brown background with light, cream-colored blotches. Blotches coalesce into two broad, broken stripes extending from behind eyes to the groin, stripes about width of eyes. Another, more diffuse band of cream middorsally, interrupted with dark brown. A light, triangular spot of cream between the eyes, and a light blotch above the lip on each side. Both front and hind limbs barred with dark brown and cream; the hands almost entirely dark brown. Belly immaculate white, throat white with dark brown, longitudinal lines. Forelimbs white, edged with a fine pattern of dark brown vermiculations; this pattern of brown extends laterally along the sides of the belly, and completely covers the ventral surface of the hind legs. Hands and feet dark brown ventrally.

Snout-vent 32.0 mm, tibia length 15.7, head width 12.6.

Variation. The ratio of brown to cream on the dorsal surface varies considerably; the type represents an intermediate condition. However, in all specimens, even the smallest, some vestige of the two light bands on the back is always discernible; it is most obscure in very

light individuals, where it blends in with the background. Ventral coloration is somewhat variable, especially in the density of brown pigmentation on the throat and underside of the limbs; some individuals are virtually solid brown, while others have a very faint pattern of brown vermiculations. This variation is not sexually dimorphic; both males and females have dark throats.

Males possess a variable, but generally poorly developed, raised femoral gland ventrally on the thigh. In the best developed individual (FMNH 216594), the glands are about one-half the length of the thigh, twice as long as wide, and perfectly oval. Under magnification, the granular structure of the gland can be seen through the skin, although the surface of the gland is smooth. Males also possess a weakly developed nuptial pad on the inside of the first finger. The femoral glands are generally weakly developed, and in most cases are only barely visible. Since all females contained mature ova, both sexes are presumably at their height of reproductive activity, implying that the femoral glands are never strongly developed.

All females larger than about 25.0 mm possess some large, pigmented ova ready for laying, as well as a few small, unpigmented ova. Sexual maturity appears to be reached in females at 25 mm SV; two individuals at 23.9 and 23.6 mm had a few mature ova, but most were small and unpigmented, and other individuals less than 24 mm SV had only immature ova.

Measurements and body proportions are given in Table 2.

Comparisons. Five species of *Nyctibatrachus* have been described to date: *N. humayuni* Bhaduri and Kripalani, *N. major* Boulenger, *N. pygmaeus* (Gunther), *N. sanctipalustris* Rao (with two subspecies), and *N. sylvaticus* Rao.

TABLE 2

SNOUT-VENT LENGTH (MM) AND TIBIA LENGTH AND HEAD WIDTH AS PROPORTION OF SV IN ADULTS OF *Nyctibatrachus aliciae*

	Females	Males
Snout-vent		
range	20.4-33.5	21.8-24.9
mean	26.5	22.7
Tibia length		
range	0.46-0.54	0.49-0.53
mean	0.501	0.504
Head width		
range	0.38-0.44	0.38-0.42
mean	0.404	0.395
Sample size	25	8

Of these species, all but *N. pygmaeus* are very similar to *N. major*; they are large (adults over 40 mm SV), generally dark with irregular dark mottling, and apparently represent slight variations from *N. major*. All of these species are readily distinguishable from *N. aliciae* on the basis of adult size and on dorsal color pattern. In our large series of sympatric *N. major*, a light banding pattern may be faintly visible in some juveniles, although they invariably become dark brown with age. The webbing on the hind feet is also less extensive in our *N. major* (see below).

Nyctibatrachus aliciae differs from *N. pygmaeus* in several characters. Besides the differences shown in Table 1, *pygmaeus* is smaller (3 syntypes 18.7, 19.1, 23.1 mm) and lacks expanded toe disks and dorsolateral light bands.

Ecological Notes. This species was distributed throughout the habitats sampled, from 105 to 840 m elevation. Most (28) were taken at 310-350 m in evergreen forest; in addition, 3 were collected at 650-660 m in evergreen forest, one from moist deciduous forest at 105 m, and 3 from an area of secondary

growth at 840 m. All of the specimens were taken in close association with water: 21 from the banks of permanent streams (generally within 1 m of the stream), 8 were on rocks in mid-stream, 5 were actually in the water, and one was in a temporary pool. We cannot say whether this species is always restricted to aquatic habitats, or if this distribution is a phenomenon of the breeding season.

Twenty of our specimens were collected on rocks, 4 on bare soil, and 3 on dead leaves. With two exceptions, all specimens were found after dark, suggesting that, like other members of the genus, this species is nocturnal.

***Nyctibatrachus major* Boulenger (Plate I)**

Nyctibatrachus major Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 114, pl. 12, fig. 2 — Malabar and Wynad.

Material. 23 adult females 40.1-53.6 mm SV, mean 47.9; 35 adult males 36.3-51.8 mm, mean 43.6; 154 juveniles and subadults 14.9-37.3 mm, those 14.9-20.0 with vestige of tail. Tibia 0.47-0.53 of SV in females, mean 0.496 (n=12); in males 0.48-0.55, mean 0.512 (n=12). Head width 0.43-0.47 of SV in females, mean 0.451 (n=12); in males 0.43-0.47, mean 0.447 (n=12).

Pillai (1978b) has provided a recent redescription of *N. major* based on a series of 42 individuals from Wynad, one of the type localities, approximately 400 km north of our collecting locality. Because the description is relatively complete, we will only note points where our collection deviates substantially from Pillai's.

Our adult specimens range from light tan to dark brown, although light adults are uncommon. As Pillai noted, juveniles tend to be lighter than adults, although they also range from light yellow-tan to dark brown. In some juveniles (about 10%), a pair of diffuse, light cream lines extend from the eyes about half

way to the vent on the dorsum, superficially resembling similar bands found in *N. minor* (see below). However, the bands are much wider and more diffuse in *major*.

Pillai (1978b) stated his specimens lack circummarginal grooves on the finger disks, but have both deep circummarginal grooves and longitudinal dorsal grooves on the toes. In our frogs the toes have very shallow, poorly defined grooves. It is impossible to determine how much of this difference is an artifact of preservation and how much is due to geographic variation.

Adult males have well-developed femoral glands. These glands are oval, about half the length of the femur, and one-half to one-third as wide as long. The glands are slightly raised, yellow-cream in color, and sharply differentiated from the skin of the surrounding thigh. Under magnification the glandules are visible through the skin, giving the area a granular appearance. Similar glands are also present in the type series of *N. major* (Barry Clarke, personal communication), and in several other species of *Nyctibatrachus* and *Nannobatrachus* (Table 1).

The smallest adult female (40.3 mm) had a few pigmented ova. All larger females contained ripe, pigmented eggs with black and cream colored poles, as well as a few small, white ova.

Larvae. Twenty-one samples of larvae ranging from Stage 25 to Stage 41 (Gosner 1960) agree closely with Pillai's description of larval *N. major* (Pillai 1978b). The principal difference between our larvae and those illustrated by Pillai lies in the labial lobes. In ours, the lateral portions of both lips are formed by wide lobes that flank 4 median lobes on the lower lip. As only a slight modification of Pillai's figure would bring it into correspondence with our tadpoles, we believe that this

difference is merely a matter of interpretation.

The limbs of pre-metamorphic larvae are like those of adult *major* in one particular feature that distinguishes that species from *N. aliciae*: the dorsal surfaces of the disks lack a longitudinal groove. In our samples, head-body length measured 13.33-14.16 mm in the largest Stage 25 larvae, 17.25-17.75 at mid-development (Stages 32-36), and 16.67-18.0 near metamorphosis (Stages 40-41). Tail lengths varied from 1.90 to 2.25 times head-body length, and maximum tail depth from 0.21 to 0.26 of tail length. Transforming individuals with tail stumps varied from 14.9 to 19.4 mm SV.

Ecological Notes. Altitudinal distribution was extensive: 110 m — 1, 240-290 — 8, 310-365 — 152, 630-660 — 36, 840-920 — 6. Half (106) of the transformed individuals were captured in water; the remainder were on stream banks or in seepage areas. As these hill streams have rocky banks, it is not surprising that a third (34) of those seen out of water were on rocks; others were on sand (25), on dead leaves (18), under dead leaves (14), under rocks (4), on logs (2), on the base of a tree (1), and on a low herb (1). About half of the total sample was obtained during daylight hours, including half (51) of those captured in water, all of those from under dead leaves, and two-thirds of those from sandy banks.

One tadpole was found in a pothole of a rocky stream bank, 31 (5 samples) in side pools of streams, 29 (1 sample) in a bank seepage, 106 (12 samples) in shallow pools with weak to moderate current, and 2 (2 samples) in seepages close to small streams.

***Nyctibatrachus minor* sp. nov.** (Plate II)

Diagnosis. A small species of *Nyctibatrachus* which may be distinguished from all other forms by its small size at sexual maturity (maximum SV about 22 mm), the complete

absence of webbing on the hind feet, the presence of a distinct, dorsolateral glandular fold, the lack of femoral glands in sexually mature males, and lack of pigment in mature ova.

Holotype. Field number RFI 31175, an adult female collected 30 May, 1982, from Ponmudi, Trivandrum District, Kerala, at 350 m elevation. Deposited in NMNHI.

Paratypes. 3 adult females, 18 adult males, 9 juveniles and subadults. FMNH 216603-18; 14 deposited in NMNHI.

Description of holotype. Habitus squat and flattened. Snout rounded, no canthus rostralis. Nostrils dorsal, raised slightly above the snout. Internarial distance approximately equal to interorbital distance; nostrils about equidistant between orbit and tip of snout. Upper eyelids extremely reduced, covering less than one-quarter of the eye; interorbital distance three times width of eyelid. A faint, interrupted supratympanic fold. Tympanum indistinct, the anterior border barely visible as a small crescent well separated from the eye.

Forelimbs stout, fingers moderate, with no vestige of webbing. Third finger longest, second and fourth subequal. Fourth more slender than others. Thumb short and robust. Tips of the fingers expanded into very small disks slightly wider than subterminal phalanx. No circum-marginal groove separating the upper and lower surfaces of the fingers. A weak dorsal groove on the left third finger; otherwise, disks without a longitudinal dorsal groove. Subarticular processes weakly developed, barely distinguishable from the ventral surface of the fingers.

Hind legs stout, moderately short; the tibio-tarsal joints meet but do not overlap when the legs are bent at right angles to the long axis of the body. Tibia 0.48 of SV. Toes long and slender, with no vestige of webbing between them. Tips of toes expanded into small, oval disks, slightly wider than subterminal phalanx.

Disks with a strong, longitudinal, dorsal groove; no circummarginal groove separating the upper and lower surfaces of the toes. Sub-articular processes poorly developed; a small oval inner metatarsal tubercle. A very short, crescentic fold extends from the inner metatarsal tubercle proximally about the length of the tubercle, then running in a straight line along the long axis of tarsus for about an equal distance. A smooth ridge extends along the outer edge of the fifth toe from its tip to the level of the inner metatarsal tubercle.

A series of well-defined, glandular ridges on head and back. A ridge extends from upper lip along midline of snout to between nostrils, at which point it bifurcates into a pair of ridges extending nearly to each eye. A pronounced transverse ridge between eyes. A pair of curved, dorsolateral folds from behind eyes, forming an hourglass pattern extending three-quarters of distance to groin. An additional pair of ridges forms an "X" pattern on anterior half of back, starting at same level as dorsolateral fold, but contained within them. A faint, interrupted supratympanic fold from eye to near shoulder.

Upper surface of arms and legs with irregular folds extending length of limbs. Some extremely minute granulations on eyelids and dorsal surface of head; otherwise, skin smooth. Ventrally, skin smooth.

Snout-vent 21.5 mm, tibia length 10.4, head width 8.4.

Color above light tan with dark brown markings surrounding most of longitudinal folds. A pronounced dark line between nostril and eye, a dark line between eyes, a brown "X" on the anterior half of the body. Anterior and posterior quarters of dorsolateral folds dark brown, area between folds light tan. A thin, white band along inside of anterior half of each dorsolateral fold. A few additional

smudges of dark brown on the sides, and a white spot at the corner of the jaw just below each eye. Forelimbs strongly barred with dark brown; hindlimbs uniform tan. Beneath immaculate white with an extremely fine speckling of black along margins of body, limbs, and lower jaw.

Variation. The ground colour varies from nearly uniform chocolate brown to very light buff; the type is near the light side of this range, and represents the modal color. The striping pattern of the holotype is common to all individuals, even the smallest juveniles. However, different aspects of the pattern are more or less distinct depending on the background color. In dark individuals, the pair of white lines following the dorsolateral folds are extremely distinct, while the dark markings are relatively obscure; the opposite is true of light individuals. Some specimens have a distinct pattern of dark brown crossbands on the hind limbs as well as the forelimbs, and in some the dark lines surrounding the dorsolateral folds may be uninterrupted for their entire length. The ventral coloration is always immaculate white.

All females contained large, mature, white ova. Males have no external secondary sexual characters, and lack the femoral glands found in the other members of the genus (Table 1).

Metamorphosis apparently occurs at a very small size; our smallest individual (7.7 mm SV) has only a slight vestige of the tail above the anus. The tadpole has not been positively identified.

Comparisons. Of the five species of *Nyctibatrachus* previously described (see *Comparisons* of *N. aliciae*), four are clearly closely allied to *N. major* and may be distinguished from *N. minor* on the basis of size (all are about 40 mm SV, while the largest *N. minor* is 21.5 mm SV). The only species of com-

parable size is *N. pygmaeus* (Gunther). We have compared our material to 3 syntypes of *N. pygmaeus* (BMNH 1947.2.4.47, 1947.2.4.51, 1947.2.4.57). *Nyctibatrachus minor* differs from them in lacking webbing on the hind feet (*pygmaeus* is half to two-thirds webbed), in the pattern of glandular ridges on the head (the ridges are irregular and short in *pygmaeus*), in having a dorsolateral glandular fold (a few, broken ridges may be present in *pygmaeus*, but never a continuous fold), in the distinctive color pattern, and in being immaculate white beneath (*pygmaeus* is light brown). *Nyctibatrachus minor* differs from *N. aliciae* in size, color pattern, webbing of the hind foot, in lacking femoral glands in males, and in the females having unpigmented, mature ova. The last two characters are apparently unique for the genus (Table 1).

Measurements and body proportions given in Table 3.

Pillai (1978b) suggested that the presence of circummarginal grooves on the disks of the toes may be a useful generic character for

Nyctibatrachus. However, such grooves are weakly developed or absent in some individuals of our *N. major* sample, well-developed in *N. aliciae*, but absent in *N. minor*.

Ecological Notes. All specimens were collected in evergreen forest at 310-375 m elevation. Since similar habitats were searched at higher elevations, we conclude that *N. minor* is restricted to relatively low elevations. Of the 30 specimens for which we have ecological data, all but 5 were collected either in or immediately adjacent to small streams or seepage areas, both by day and night. A favored microhabitat site was on or under dead leaves in seep areas (22 individuals), a position from which males were often heard calling.

Nyctibatrachus sp.

Two tadpoles having the characteristic oral disk of *Nyctibatrachus* (Bhaduri and Kripalani 1955, figs. 5 and 6; Pillai 1978b, fig. 1B) differ from any described to date. Because of their stages of development, they cannot be assigned to a species of adult.

Nyctibatrachus sp. A

A single tadpole in Stage 36 captured in a seepage area on a steep slope at 375 m above sea level. It differs from larval *N. major* in having only two median lobes on the lower lip (instead of 4), a smooth margin on the upper median lobe, the origin of the dorsal fin about two-thirds of head-body length behind the end of the body, and much narrower fins. It also differs from larval *N. humayuni* in all the preceding characters except the first. The limbs are not sufficiently developed for comparison with adults.

Head-body oval, snout rounded but narrower than in *N. major*, body flattened above, rounded below; maximum width midway between eyes and end of body, 0.60 of head-body

TABLE 3

SNOUT-VENT LENGTH (MM) AND TIBIA LENGTH AND HEAD WIDTH AS PROPORTION OF SV IN ADULTS OF *Nyctibatrachus minor*

	Females	Males
Snout-vent		
range	20.4-21.5	15.1-18.2
mean	21.1	17.3
n	4	18
Tibia length		
range	0.47-0.51	0.48-0.53
mean	0.486	0.501
n	4	10
Head width		
range	0.38-0.40	0.39-0.42
mean	0.395	0.405
n	4	10

length, depth 0.85 of width; eyes dorsolateral, not visible from below, eyeball 0.12 of head-body length; interorbital 0.29 of head-body width, subequal to eye-snout distance; nostrils dorsolateral, open, rim with a distinct mid-dorsal projection, internarial distance slightly narrower than interorbital. Oral disk ventral, subterminal, without denticles; 0.32 of head-body width; lips expanded and lobulate; a wide lateral lobe forming lateral third of the disk; upper lip with a single wide median lobe about 1.5 times width of lateral lobes, notches separating median from lateral lobes deep; lower lip with a pair of narrow median lobes marked by shallow notches; margins of all except upper median lobe with single row of short papillae; a band of indistinct, short inframarginal papillae across bases of lower median lobes; a row of 7 short papillae across base of upper median lobe; upper beak gently curved, black along its margin, finely serrate; lower beak V-shaped, black along its marginal third, serrae longer and coarser than those of upper beak. Spiracle sinistral, midway up side, tube free from body wall near tip, snout-spiracle distance 0.49 of head-body length. Anal tube dextral. Tail 2.59 times head-body length; heavily muscled, margins straight, tapering gradually to narrow tip; maximum depth 0.16 of tail length; caudal muscle 2-3 times deeper than fins except at tip; origin of dorsal fin far behind end of body. No glands visible. Lateral line pores in conspicuous rows along side of snout and around eye; in a dorsolateral row to end of body, continuing on tail at base of dorsal fin, and in a ventrolateral row continuing along middle of caudal muscle.

Tadpole greyish brown, with small dark irregular spots over all surfaces except ventral fin and underside of head-body.

Head-body length 9.0 mm, total length 32.

Nyctibatrachus sp. B.

A single tadpole (Stage 25), caught in a pool of a small stream trickling over sand, differs from all larvae of *Nyctibatrachus* described or figured in having a much more slender habitus, very small eyes, a very narrow median lobe on the upper lip, inframarginal papillae across the lateral lobes of the upper lip, and fully pigmented, heavy beaks. The relatively small eye may be a function of small body size or early development. However, two Stage 25 tadpoles of *N. major* have much larger eyes (0.09 of head-body length as opposed to 0.03) and the observed range of relative eye size in *N. major* (Stages 25-41) is only 0.08-0.11. The other distinguishing features of this tadpole do not appear to be size-related.

Head-body an elongate oval, snout rounded but narrowed; strongly flattened above, weakly so below; maximum width in rear third of body, 0.52 of head-body length, depth 0.68 of width; eyes dorsal, very small, eyeball 0.03 of head-body length; interorbital 0.20 of head-body width, much less than eye-snout distance; nostrils dorsolateral, open, midway between eyes and tip of snout, a small mid-dorsal projection, internarial slightly wider than interorbital. Oral disk ventral, subterminal, without denticles, 0.39 of head-body width; lips expanded, lobulate; a single, narrow, median lobe on upper lip; 4 subequal median lobes on lower lip; remainder of both lips occupied by a wide lateral lobe; a single row of short, slender, marginal papillae on all lobes, those of median upper lobe distinctly narrower than others; a zigzag, transverse row of thick, short, inframarginal papillae across each lateral lobe of upper lip, papillae closer to beak than to margin of lip; a zigzag, transverse row of similar papillae across 4 median lobes of

lower lip, papillae closer to margin than to beak. Beaks heavy, completely black, margins coarsely serrate. Spiracle sinistral, half way up side, tube free from body near end, snout-spiracle distance 0.41 of head-body length. Anal tube dextral. Tail 2.07 times head-body length; heavily muscled, dorsal margin weakly convex, ventral margin straight, tapering gradually from middle to narrow tip; maximum depth 0.21 of tail length; caudal muscle much deeper than fins until distal fifth; origin of dorsal fin far behind body. No glands. Lateral line pores not visible.

Entire tadpole pinkish dark gray; caudal muscle dusted with melanophores with a few irregular pigment-free areas; dorsal fin with melanophores along juncture with muscle, otherwise fins without pigment.

Head-body length 9.25 mm, total length 28.1.

Rana beddomi (Günther)

Polypedates beddomi Günther, 1875, Proc. Zool. Soc. London, 1875: 571, pl. 43, fig. B. — Anamallai, Malabar, Sivagiri, Travancore.

Rana beddomi, Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 55.

Material. 9 adult females 45.1-60.1 mm SV, mean 49.4; 12 adult males 35.4-49.5 mm, mean 43.1, 15 juveniles 22.6-35.0 mm, Tibia 0.52-0.65 of SV in females, mean 0.627; 0.57-0.67 in males, mean 0.596. Tympanum 0.068-0.086 of SV in females, mean 0.078; 0.095-0.118 in males, mean 0.104.

Our specimens agree very closely with Günther's original description and figure. Webbing extending to disk on fifth toe and on lateral sides of toes 1, 2, and 3; medially, webbing extends to distal subarticular tubercle on second toe, and midway between first and second tubercles on third toe. Fourth toe webbed to second subarticular tubercle on both sides. Subarticular tubercles well developed.

Dorsally, skin smooth or covered with fine granulations, more pronounced around anus and angle of jaw. A series of extremely thin, longitudinal folds on the back of some individuals. Ventrally, skin smooth, with a granular area on thighs near anus.

Coloration variable; the commonest pattern consisting of light pinkish-tan background with an irregular speckling of dark brown. In some individuals, dorsal background color dark brown. A black streak along supratympanic fold from eye to shoulder, continuing forward along canthus rostralis to nostril. A second dark streak anterior to tympanum from the lower margin of eye to jaw. Front and hind limbs faintly barred with dark brown, as are lips. Ventrally white with brown reticulations present on throat and sides of body; underside of legs immaculate yellow-white.

Males are smaller than females and have a much larger tympanum. In males, the tympanum is as large or larger than the eye; in females, it is about two-thirds the eye diameter. In addition, males have small, pointed spicules distributed along the margins of the jaw, throat, and lateral margins of the belly; in large males these may become brown and hardened. Males also have enlarged nuptial pads on the inside of the first finger.

All females below 30 mm SV were immature, while those above 50 mm contained enlarged, pigmented ova. Two 45 mm females contained both mature and immature ova, suggesting that sexual maturity is reached at about this size.

Taxonomic Notes. We use the name *beddomi* in the restricted sense of Günther (1875), and recognise *Rana brachytarsus* as a distinct species (see below). These two species are distinguished on the basis of amount of webbing and size. The smallest sexually mature *beddomi* female we have seen is 45 mm SV,



Habitat of larval *Rana beddomi* at 900 m.

while the largest *brachytarsus* is 43 mm SV. In comparing our material to three syntypes of *R. beddomi* (BMNH 1947.2.27.73, 82, 84), we note that this small typic series is a composite of *R. beddomi* and *R. brachytarsus*. One of the syntypes (1947.2.27.73) has webbing as described above for *beddomi*. It is a female, 45.2 mm SV, with tiny, immature ova, and has not reached sexual maturity. The other two individuals have the more extensive webbing found in *brachytarsus* and are smaller: male 26.5 mm, female 39.3 mm. The female (1947.2.27.82) is sexually mature, with a thickened oviduct and ripe, pigmented ova. Thus, the first specimen is a subadult *R. beddomi*, while the other two syntypes are referable to *R. brachytarsus*.

Larvae. Three samples of tadpoles, collected from rock faces, fit Annandale's (1918) description of larval *R. beddomi* very closely and agree among samples and with adult *beddomi* in having the third toe webbed to the middle subarticular tubercle and the fifth toe webbed to or almost to the base of the disk. As in the case of the tadpoles observed by Gravely (cited in Annandale 1918), those we collected made short, skittering jumps across the rock faces whenever they were closely approached.

The early development of the hind limbs, which Annandale (1918) inferred (correctly we think) on the basis of the wide range in size within stages 40-41, appears to be related to the skittering habit. Although used in this case to escape herpetologists (and other predators, presumably), probably the principal function of this behaviour is to enable the tadpoles to move from one tiny, shallow pool to another across slightly drier surface irregularities of the home rock face.

Head-body lengths (mm): 4.33 (Stage 30), 6.25-9.25 (Stage 40). Snout-vent: 6.75-12.6

(Stage 41), 11.9-13.9 (Stage 42), 12.0 (Stage 43), 13.9 (Stage 44). Total lengths: 17.5-17.8 (Stage 30), 22.5-26.4 (Stage 40), 27.3-30.2 (Stage 41).

Measurements on our specimens bear out Annandale's comments on the odd body proportions of larval *beddomi*. Their eyes are relatively larger than those of other tadpoles of tropical Asia, 0.16-0.19 of head-body length. The tail is long (2.5-3.3 times head-body length) and very slender (maximum depth 0.08-0.10 of tail length).

Denticle rows are 4+4/2+2:II in all but one of the 16 counted; the exceptional specimen had 5 divided rows on the upper lip.

Ecological Notes. We found most of our specimens in evergreen forest at 310-370 m (29 individuals); additional specimens came from moist deciduous forest (3 at 105 m), gallery forest (1 at 900 m), and moist semi-evergreen forest (1 at 260 m). Twenty-three were collected away from streams in forest, 11 along the banks and one in the water of permanent streams, and one in a dry stream bed. Fifteen frogs were collected on small rocks, 12 on dead leaves, and 5 on the soil surface; in addition, one each was found under the soil and on a log on the forest floor. Larvae were collected from rock faces over which a thin film of water flowed at 330, 890, and 900 m (Plate III). The highest site was completely open to the sky with the nearest trees about 10 m distant. The other sites were inside forests and shaded.

Rana brachytarsus (Günther) (Plate II)

Polypedates brachytarsus Günther, 1875, Proc. Zool. Soc. London, 1875: 572 — Anamallais and Sivagiris.

Material. 47 adult females 28.6-44.7 mm SV, mean 34.8; 25 adult males 25.1-33.7 mm, mean 29.5; subadult females 25.0, 25.3 mm.

Tibia 0.59-0.65 of SV in females, mean 0.621 (n=10); in males 0.64-0.84, mean 0.74 (n=10).

The webbing extends to the disk on the fifth toe and on the lateral sides of toes 1, 2 and 3. Medially, the webbing extends to the distal subarticular tubercle of the third toe, and to between the middle and distal subarticular tubercles of the fourth. The disks of the toes and the subarticular tubercles are less well developed than in *R. beddomi*. Dorsally, the skin is thrown into a series of longitudinal folds, which reach their densest concentration on the anterior portion of the back. These folds are much thicker and more prominent than in *R. beddomi*. Ventrally the skin is smooth, except for a granular patch near the anus.

Color pattern consists of a tan dorsal background with a variable number of short, longitudinal brown streaks. Some individuals have only a trace of this pattern, others are nearly completely brown. About 10% have a distinct, white middorsal stripe from the eyes to the vent. A dark brown band between the eyes is generally present. A black stripe follows the supratympanic fold and canthal ridge as in *R. beddomi*, and a second stripe, just anterior to the tympanum, connects the eye and upper lip. The limbs and lips are barred with dark brown. Ventrally white, rarely with a few brown spots on the throat. The legs are yellow on the ventral surface of the thighs and calves.

This species exhibits sexual dimorphism similar to that of *R. beddomi*, although it is less extreme. Males have enlarged nuptial glands on the inside of the first finger, and some males have spicules on the throat, lower jaw, and sides of the body. However, these are only rarely blackened, and more often the sides of the body have increased granulations

rather than conical spicules. The spicules on the ventral surface of the feet are very dense in males and are usually blackened and stiff. In both males and females the tympanum is about two-thirds of the eye diameter.

All females above 28 mm SV contained enlarged, pigmented ova.

Taxonomic Notes. Boulenger (1882) considered *brachytarsus* (Günther) to be a synonym of *R. beddomi*, and all subsequent authors have followed this opinion. We clearly have two species closely allied to *R. beddomi*, separable on the basis of size, webbing, coloration, dorsal skin folds, and tympanic size and density of spicules in males. We have examined one syntype of *brachytarsus* (BMNH 1947.2.27.1307) which is similar to our sample in size (syntype a mature female 36.1 mm), dorsal skin folds, and tympanum size. The webbing of the syntype is somewhat less extensive than in our series, extending to the distal subarticular tubercle on the medial side of the third toe, and the dark canthal stripe is lacking. However, the syntype is from the Anamallai Hills about 200 km north of Ponmudi, and we attribute these differences to geographic variation.

We have not seen the second syntype of *brachytarsus*. However, on the basis of its size (55 mm, as reported by Boulenger 1920), it seems likely that the type series of *brachytarsus* is a composite of that species and *beddomi* just as is the type series of the latter (see above). We therefore designate the small female, BMNH 1947.2.27.1307, as the lectotype of *R. brachytarsus* (Günther).

Ecological Notes. This species has a broad ecological distribution. We found specimens from 100 to 950 m elevation (9 from 105-250 m, 35 from 260-350 m, 5 from 480-650 m, 22 from 860-950 m) distributed in evergreen forest (40), moist deciduous forest (10), gal-

lery forest (2), secondary growth (2), and open grassy areas (17). Most individuals (54) were collected away from water on the forest floor, although some were found in or along streams (18). Thirty-five were collected on rocks, 29 on dead leaves, 7 on bare soil, and 2 under dead leaves. Seventeen were caught in a seepage area at 900 m where a thin film of water flowed over exposed bedrock, and a number of calling males were taken from crevices in bedrock after dark.

Rana diplosticta (Günther)

Ixalus diplosticta Günther, 1875, Proc. Zool. Soc. London, 1875: 574, pl. 43, fig. 3 — Malabar.

Rana diplosticta Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 58.

Material. 4 adult females 23.6-25.2 mm SV, mean 24.6; 2 adult males 18.7, 20.0 mm. Tibia 0.56-0.62 of SV in females, mean 0.588; 0.60 in both males.

Toes less than one quarter webbed, webbing extending to proximal subarticular tubercle on medial side of third and fourth toes. Fingers and toes with large disks with strong circum-marginal grooves separating upper and lower surfaces. The back has a series of longitudinal folds; the head, sides, and belly are smooth. A strong, curved supratympanic fold from eye to shoulder. Tympanum well-developed in both sexes, about one-half eye diameter.

In life, this species is reddish-brown dorsally, with a black canthal and tympanic streak. The iris is greenish-gold above and black below, the line of demarcation coinciding with the upper edge of the dark canthal stripe. The dorsal color pattern is consistent among our six specimens and corresponds very well with Günther's (1875) figure. Above dark light tan with a dark brown band of varying intensity between eyes. Entire loreal region from canthus rostralis to upper lip is dark brown.

Dark brown blotches may be present on the lateral surfaces; blotches symmetrically arranged on both sides of body. A dark brown spot invariably present just dorsal and anterior to the hind limb. Limbs tan crossbarred with dark brown. Ventrally light brown diffused with a fine reticulated pattern of dark brown, with most of the darker color concentrated on the throat and thighs. A dark brown triangular patch surrounding the anus.

All four females contain very large, pigmented ova with black and tan poles. Males have a series of 5 very large, black, sharp nuptial spines on the medial surface of the first finger. These spines were not noted by Boulenger (1920), who stated that males lack secondary sexual characters.

Taxonomic Notes. This small series is apparently the first collection of this species since those obtained by Jerdon and Beddome a century ago. Boulenger (1882) suggested that this species and *R. leptodactyla* may be conspecific, although he later (Boulenger 1920) treated them as full species. We have compared our material to syntypes of *R. diplosticta*, and the agreement with that species is very close. It is not known whether *R. leptodactyla* also has well developed nuptial spines in males.

Ecological Notes. All specimens were collected at 950 m elevation, far from streams or ponds. Five were found in evergreen forest, and a single specimen was in gallery forest. Three frogs were found under dead leaves, and one each on bare soil, dead leaves, and a rock.

Rana semipalmata Boulenger

Rana semipalmata Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 56, pl. 4, fig. 3 — Malabar.

Material. 3 adult females 32.0-35.5 mm SV, mean 33.6; 3 adult males 27.4-29.3 mm,

mean 28.3. Tibia 0.55-0.62 of SV in females, mean 0.576; in males 0.50-0.52, mean 0.510. Tympanum diameter 0.085-0.097 of SV in females, mean 0.092; in males 0.120-0.135, mean 0.127.

A small ranid, similar in general appearance to *R. brachytarsus*, but distinguishable on the basis of less webbing and size of tympanum. Webbing extends to the distal subarticular tubercle on the fifth toe and on the lateral side of the third, and midway between the proximal and the second subarticular tubercle on the fourth toe.

Dorsally tan or light brown, with longitudinal folds usually on the back. A dark brown stripe between the eyes. A broken U-shaped stripe open to the rear extends across the back from the level of the pectoral girdle. Limbs barred with black. No canthal stripe.

All three females contained pigmented, mature ova, and all 3 males have nuptial pads on the first finger and enlarged glands covering the ventral surface of the thighs. Males have a band of very small transparent spicules across the chest and around the margins of the jaw. Tympanum diameter is absolutely as well as relatively larger (see above) in males.

Taxonomic Notes. We have examined one of the two syntypes (BMNH 1947.2.29.51), a male that agrees very closely with our material. The syntype has nuptial pads and femoral glands. Boulenger's (1920) statement that males of this species lack secondary sex characters is in error.

Ecological Notes. We found 5 specimens in evergreen forest (4 at 330-360 m above sea level) and 1 in moist deciduous forest at 105 m. Three were collected 3-5 m from small permanent streams; the other 3 were well away from water in the forest. We found 2 frogs on dead leaves, 2 under leaves, and 2 on rocks. Two males were calling from seepage

areas on exposed bedrock.

The large related species, *R. beddomi*, was found in sympatry with both small forms, *R. brachytarsus* and *R. semipalmata*, but the two last were found together only at one site at 105 m.

This is the first report of additional specimens of *R. semipalmata* since the original description.

Rana keralensis Dubois

Rana keralensis Dubois, 1980, Bull. Mus. Nat. Hist. Nat. Paris, (4), 2: 928 (replacement name).

Rana verrucosa Günther, 1875, Proc. Zool. Soc. London, p. 567 — Malabar.

Material. 1 adult female 50.6 mm SV, 6 subadult females 36.3-43.7 mm; 9 adult males 37.5-42.3 mm, mean 40.4; 24 juveniles 14.4-32.9 mm. Tibia 0.55-0.62 of SV in females, mean 0.585 (n=7); 0.55-0.62 in males, mean 0.572.

Dorsal coloration somewhat variable, although always light brown with dark brown bars across the body. A light tan vertebral stripe present or absent. The posterior side of the thigh is bright yellow marbled with black in life, dark brown marbled with white in preservative. Males have a well developed nuptial pad on the inner surface of the first finger. Of our 7 females, only the largest appeared to be sexually mature as she contained a few darkly pigmented ova. All of the other females contained only immature ova. Our smallest individual (SV = 14.4 mm) has a small vestige of its tail remaining, and presumably represents the size at metamorphosis.

Larvae. Five samples of tadpoles agreeing with Annandale's (1918) description (as *R. verrucosa*) were collected. A premetamorphic larva (Stage 41) has the webbing and foot form typical of adults, some of which were caught at the same site.

Head-body lengths (mm) : 6.6 (Stage 30),

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9.75 (Stage 34), 11.25 (Stage 37), 9.67-11.1 (Stages 39-41). Maximum total length 29.8 mm (Stage 41). Head-body width 0.59-0.62 of length, depth 0.73-0.79 of width; Width of oral disk 0.35-0.39 of head-body width. Denticles I : 1+1/III, the outermost lower row two-thirds length of others.

Ecological Notes. As Daniel (1975) stressed, very little is known of the ecology of this species. We found all but one specimen at 100-300 m elevation, with a single frog taken at 710 m. The species inhabits a wide range of both disturbed and primary forest situations, including evergreen forest (22), secondary growth forest (13), moist deciduous forest (2), rubber plantation (1),

and in a clearing (1). About half of our specimens (21) were collected away from water; the remainder were found in or along the banks of permanent streams (15) or in temporary rain pools (3). Individuals were always found on the ground, either on dead leaves (19), small rocks (4) or bare soil (6). About two thirds (26 of 40) of our specimens were found in small forest clearings, either along trails or roads, or in treefall areas. The samples of larvae were collected in water-filled silty ruts in a road through forest (3) and in pot-holes of rocky stream banks (2). Annandale also found tadpoles in a pot-hole alongside a stream.

(to be continued)